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Evaluating Asphalt Cap Effectiveness at Superfund Site

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E. W. Repa, E. F. Tokarski, R. T. Eades, & Jonathan G. Herrmann

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JRB Associates
8400 Westpark Drive
McLean, VA 22102

USEPA/HWERL/LPCD
26 West St. Clair Street
Cincinnati, OH 45268

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16. ABSTRACT

A two-phase interim remedial measure plan was developed for the Western Processing Co., Inc. Superfund site with the objective of reducing the quantity of precipitation contacting the site, becoming contaminated, and then running off or infiltrating through the surface. Phase I involved the implementation of a drainage control plan while Phase II, the subject of this paper, involved the installation of an asphalt cap on a portion of the site.

Cores were taken from the cap and tested to determine their intrinsic permeability and percent air voids. Intrinsic permeabilities were used to calculate hydraulic conductivities for the cores. The results of this testing showed that the cap was constructed of a relatively permeable asphalt concrete which would not, based on the hydraulic conductivities calculated, result in an impermeable cap. Consequently, achieving the interim remedial measure plan objective had to be based solely on the success of the Phase I drainage control plan.

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EVALUATING ASPHALT CAP EFFECTIVENESS AT SUPERFUND SITE

By E. W. Repa,[1] J. G. Herrmann,[2] M. ASCE, E. F. Tokarski,[3] and R. T. Eades[4]

INTRODUCTION

The Western Processing Co., Inc., Superfund site is ranked 48th out of the 786 sites on the "National Priority List" (U.S. Environmental Protection Agency 1984). The site is located within the city limits of Kent, Washington, approximately 24 km south of Seattle and occupies about 5.3 ha. An asphalt cap was placed on approximately 1.6 ha of the site at the location of an old chemical reaction pond. After cap placement, the intrinsic permeability of selected asphalt concrete cores from the cap were measured using air, clean water, and contaminated site water as permeants. Test results were then used to calculate the hydraulic conductivities of the cores. A percentage of air voids analysis was also performed as a check on the intrinsic permeability test results.

SAMPLING AND TESTING PROGRAM

A total of nine sampling locations on the cap were selected to represent the range of possible intrinsic permeabilities present: (1) coarse versus fine textured pavement mats; (2) mats versus joints; (3) longitudinal joints versus transverse joints; and (4) suspected areas of weep or infiltration. Two cores within 45.7 cm of each other (labled A and B) were obtained from each sampling location.

Intrinsic permeability tests were performed on the 18 asphalt concrete cores. Tests were performed in accordance with ASTM D 3637, "Standard Test Methods for Permeability Testing of Bituminous Mixtures" (ASTM 1984) using air as the permeant and the U.S. Army Corps of Engineers' "Standard Falling-Head Permeability Test with Permeameter Cylinder" (U.S. Army Corps of Engineers 1980) using water as the permeant. Table 1 presents the test data. In general, pavement mats exhibited the highest permeabilities and areas of suspected weep or infiltration the lowest permeabilities. The order of relative permeabilities (higher to lower) was mats, joints, and weep/infiltration.

A percentage of air voids analysis was performed on one sample from each of the nine core pairs using ASTM D 3203, "Percent Air Voids in

[1]Mgr., Solid Wastes Disposal Program; Natl. Solid Wastes Mgmt. Assoc., Washington, DC 20036.
[2]Envir. Engr., U.S. Envir. Protection Agency, 26 W. St. Clair St., Cincinnati, OH 45268.
[3]Proj. Envir. Sci., SAIC, McLean, VA 22102.
[4]Grad. Student, Univ. of Massachusetts, Amherst, MA 01003.

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TABLE 1.—Asphalt Concrete Permeability and Percentage of Air Voids Test Results

Sample location (1)	Type (2)	Thickness (cm) (3)	Intrinsic Permeability per Core Length $k/L^a \times 10^{-8}$ cm			Intrinsic Permeability $k^b \times 10^{-7}$ cm^2			Hydraulic Conductivity $K^c \times 10^{-2}$ cm/s		Air voids (%) (12)
			Air (4)	Clean water (5)	Contaminated site water (6)	Air (7)	Clean water (8)	Contaminated site water (9)	Clean water (10)	Contaminated site water (11)	
1A	Suspected weep area	10.16	1.88	1.80	—	1.91	1.83	—	1.79	—	11.9
1B		10.16	0.32	—	0.30	0.33	—	0.30	—	0.29	—
2A	Coarse textured mat	5.72	40.05	39.95	—	22.89	22.83	—	22.38	—	—
2B		5.72	25.03	—	24.96	14.30	—	14.26	—	13.98	16.4
3A	Fine textured mat	5.72	47.43	47.25	—	27.11	27.00	—	26.47	—	17.4
3B		5.72	96.32	—	96.13	55.05	—	54.94	—	53.86	—
4A	Longitudinal joint	5.08	28.51	28.22	28.21	14.48	14.34	14.33	14.06	14.05	17.4
4B		5.08	36.85	36.53	36.55	18.72	18.56	18.57	18.20	18.21	—
5A	Transverse joint	9.53	25.95	25.92	—	24.72	24.69	—	24.21	—	—
5B		9.53	13.06	—	12.93	12.44	—	12.32	—	12.08	15.0
6A	Fine textured mat	7.62	3.20	3.15	—	2.44	2.40	—	2.35	—	—
6B		7.62	5.15	—	5.14	3.92	—	3.92	—	3.84	12.4
7A	Coarse textured mat	8.89	25.90	25.86	—	23.03	22.99	—	22.54	—	17.5
7B		8.89	12.79	—	12.75	11.37	—	11.33	—	11.11	—
8A	Suspected infiltration area	10.16	6.41	6.35	—	6.51	6.45	—	6.32	—	11.8
8B		10.16	3.16	—	3.13	3.21	—	3.18	—	3.12	—
9A	Suspected infiltration area	7.62	8.68	8.62	—	6.61	6.59	—	6.46	—	14.6
9B		7.62	4.35	—	4.25	3.31	—	3.24	—	3.17	—
	Average	7.83	21.39	22.37	22.44	14.02	14.77	13.64	14.48	13.37	14.93

[a] k/L = intrinsic permeability/asphalt core length.
[b] k = intrinsic permeability obtained by multiplying k/L by the measured asphalt core length, L.
[c] K = hydraulic conductivity obtained by multiplying k by the gravitational constant (g = 981 cm/s^2) and dividing that sum by the kinematic viscosity of water at 20° C ($\nu = 1.007 \times 10^{-2}$ cm^2/s).

Compacted and Open Bituminous Paving Mixtures" (ASTM 1984). Percentage of air voids analysis was chosen as a second method for testing because previous researchers (Mullen 1967; Asphalt Institute 1976) have found that percentage of air voids is directly related to intrinsic permeability and hydraulic conductivity. Percentage of air voids for core samples are also presented in Table 1. Results showed that percentage of air voids data were considerably greater than those expected for typically dense-graded impermeable asphalt concrete, i.e., 4% or less air voids.

Analysis of Results

The intrinsic permeabilities showed that the asphalt concrete cap at the site was permeable. An impermeable asphalt concrete cap should exhibit a hydraulic conductivity of 1×10^{-7} cm/s or less (Mullen 1967; Asphalt Institute 1976). Hydraulic conductivities obtained for the asphalt concrete cores ranged from a high of 53.86×10^{-2} cm/s to a low of 0.29×10^{-2} cm/s. All of the calculated K for cores obtained from the Western Processing Co., Inc., Superfund site cap (see Table 1) were from four to six orders of magnitude greater than the desired value, however, values of K as large as those obtained during this study have been reported in the literature (Hinkle 1976; Mullen 1967; Tomita 1969). The reason for these large K values in the cap are attributed to one or more of the following reasons: (1) high percentage of air voids in the pavement; (2) low percentage of tar in the mix; (3) improper compaction of the pavement; (4) use of coarse graded aggregate in the mix; and (5) cracks in the material caused by compaction, subgrade settlement, or weathering.

The reason for the high hydraulic conductivities obtained from the cores at the Western Processing Co., Inc., Superfund Site is not entirely known, but possible contributing factors are presented here. One factor that could cause the observed high K values is the mix design, which did not specify low hydraulic conductivity as an important design criteria. The mix design used for the cap at the site was a Class B asphalt concrete conforming to Standard Specification 5-04 of the Washington Department of Transportation (Washington State Department of Transportation 1984). The only deviation from the mix design was a specification that the asphalt content should not be less than 6%.

Another factor that may have contributed to the high hydraulic conductivities obtained for the cores was the need for additional compaction during installation of the cap. Conversations with on-scene personnel indicated that rainfall occurred during the paving operations. Rainfall tends to cool the mixture quicker after placement and prevent adequate compaction. A medium-weight roller was used for compacting, and seven to eight passes were made. This type of compacting may be suitable for highway applications, because the pavement receives traffic after completion, which causes further compaction. For nontraffic applications, however, the specifications for highway compaction may not result in the asphalt concrete having the desired 4% or less air voids.

Summary and Recommendations

The overall results of the evaluation indicated that the cap at the site was constructed of a permeable asphalt concrete. If a more impermeable

cap is desired, then a mix design that yields an asphalt concrete with 4% or less air voids will yield a hydraulic conductivity of 1×10^{-7} cm/s or less. The following recommendations on mix designs and construction procedures are directed at achieving low percentage of air voids in emplaced asphalt concrete, thereby attaining the desired hydraulic conductivity. The reader is referred to the Asphalt Institute manual titled, *Asphalt in Hydraulics* (Asphalt Institute 1976) for a more detailed discussion of each of the following recommendations. The recommendations are: (1) Asphalt content should vary from 6–9.5%; (2) mineral filler content should vary from 8–13%; (3) aggregate size should be matched to compacted depth to ensure proper compaction without bridging of the coarse aggregate; (4) pavement samples should be tested under both laboratory and field conditions; (5) the subgrade should be properly prepared in order to drain water under the pavement and provide a stable foundation; (6) joint edges should be sloped at a 1:1 ratio to ensure proper compaction; (7) a tack coat should be applied to joint edges when the mix is cold to ensure proper bonding; (8) the asphalt concrete should be compacted to 4% air voids; and (9) the pavement surface should be sealed with an asphalt sealer.

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Appendix II.—Notation

The following symbols are used in this paper:

g = gravitational constant;
K = hydraulic conductivity;
k = intrinsic permeability;
k/L = intrinsic permeability per asphalt core length;
L = length of asphalt core; and
v = kinematic viscosity.